

2 LITERATURE REVIEW

2.1 Overview

Due to deficiencies in the built environment, many universities and research organizations have pursued the challenge to repair or strengthen existing structures with fiber reinforced polymer (FRP) materials in flexure. This section provides a summary of the literature in the field of flexural FRP repair or strengthening of concrete structures. Topics in this section include: 1) FRP systems and failure mechanisms, 2) History of FRP strengthening, 3) FRP strengthening of reinforced and prestressed concrete structures, 4) FRP repair of prestressed concrete, 5) Fatigue behavior of reinforced/prestressed concrete, 6) Fatigue behavior of reinforced/prestressed concrete strengthened with FRP materials, and 7) An overview of existing design guidelines for FRP repair/strengthening.

2.2 FRP Repair / Strengthening Systems

Fiber Reinforced Polymer (FRP) Materials

Fiber Reinforced Polymer (CFRP) materials consist of fiber filaments embedded in an adhesive matrix. There are various types of FRPs that are commonly used for structural strengthening of concrete members including pre-cured laminates and wet lay-up systems.

Pre-cured laminate FRPs are normally available commercially in the form of a bar or strip. The pre-cured laminate is manufactured by impregnation of fibers with adhesive, which is then pultruded and cured by the manufacturer. The controlled environment used in manufacturing of the pre-cured laminate can create laminates which are stronger and stiffer per unit volume than equivalent wet lay-up laminates. The laminates typically used for concrete strengthening are unidirectional and have all of the fibers oriented in the longitudinal direction. A laminate can come in various shapes and sizes. An externally bonded wet lay-up system consists of a fiber sheet which is typically field impregnated with a structural adhesive. A unidirectional fiber sheet consists of bundles of fibers held together by thin pieces of plastic material. Fiber sheets typically come in rolls 24 ft by 300 ft. The fibers in precured strips or wet lay-up systems are available in a variety of different materials including aramid (Kevlar[®]), carbon, or glass.

A steel reinforced polymer (SRP) system was also tested as part of this research, which is a wet lay-up system with embedded high-strength twisted steel wires embedded in an epoxy matrix. SRP have several benefits over traditional CFRP materials including lower cost, better fire resistance, and compatibility with anchorage systems, but may be more difficult to install and have untested corrosion resistance. The stress versus strain behavior of some typical CFRP and SRP materials are presented in Figure 2.1. Also shown in the figure are the traditional building materials used in tension: mild steel reinforcing and high strength steel used in prestressing strands.